

I claim:

1. An aqueous dispersion, having a minimum film formation temperature no greater than about 50°C, comprising a multi-stage emulsion polymer made by a process that comprises:

- 5                   a first polymerization stage, in which a first monomer mixture having a calculated glass transition temperature of at least about 50°C is polymerized via free radical emulsion polymerization to obtain a first-stage emulsion polymer, the first monomer mixture comprising:
- 10                         from about 80 to about 99.5% by weight of one or more ethylenically unsaturated non-ionic monomers;  
                              from 0 to about 5% by weight of one or more ethylenically unsaturated weak acid monomers;  
                              from 0 to about 5% by weight of one or more  
15                         ethylenically unsaturated strong acid monomers; and  
                              from 0 to about 10% by weight of one or more ethylenically unsaturated monomers containing a keto group,  
                              wherein the first monomer mixture contains at least  
20                         about 0.5% by weight of at least one of the ethylenically unsaturated strong acid monomers or the ethylenically unsaturated weak acid monomers, or mixtures thereof; and  
                              a second polymerization stage, in which a second monomer mixture having a calculated glass transition temperature from about  
25                         -30°C to about 10°C is polymerized via free radical emulsion polymerization, in the presence of the first-stage emulsion polymer, to obtain the multi-stage emulsion polymer, the second monomer mixture comprising:  
                              from about 80 to about 99.5% by weight of one or more  
30                         ethylenically unsaturated non-ionic monomers;

from 0 to about 5% by weight of one or more  
ethylenically unsaturated weak acid monomers;

from about 0.5 to about 10% by weight of one or more  
ethylenically unsaturated strong acid monomers; and

5 from about 0.5% to about 10% by weight of one or  
more ethylenically unsaturated monomers containing a keto  
group.

2. The aqueous dispersion according to claim 1, wherein the  
10 aqueous dispersion further comprises one or more of: a molecule  
containing multiple -NH<sub>2</sub> or -NH- functionality, or a polyfunctional carboxylic  
hydrazide containing at least two hydrazide groups per molecule.

3. The aqueous dispersion according to claim 1, wherein the one or  
15 more non-ionic monomers of the first monomer mixture, or of the second  
monomer mixture, or both, comprise one or more of: methyl acrylate,  
methyl methacrylate, ethyl acrylate, ethyl methacrylate, butyl acrylate, butyl  
methacrylate, 2-ethylhexyl acrylate, decyl acrylate, lauryl acrylate, isodecyl  
methacrylate, lauryl methacrylate, hydroxyethyl methacrylate,  
20 hydroxypropyl methacrylate, acrylonitrile, methacrylonitrile, acrylamide,  
methacrylamide, an amino-functional monomer, an ureido-functional  
monomer, styrene, a substituted styrene, butadiene, ethylene, propylene,  
an  $\alpha$ -olefin, vinyl acetate, vinyl butyrate, vinyl chloride, or vinylidene  
chloride.

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4. The aqueous dispersion according to claim 1, wherein the one or  
more strong acid monomers of the first monomer mixture, or of the second  
monomer mixture, or both, comprise one or more of: 2-acrylamido-2-  
methylpropane sulfonic acid, 1-allyloxy-2-hydroxypropane sulfonic acid,  
30 vinylsulfonic acid, styrene sulfonic acid, an alkyl allyl sulfosuccinic acid,

sulphoethyl methacrylate, sulphoethyl acrylate, phosphoethyl methacrylate (phosphate ester of 2-hydroxyethyl methacrylate), phosphoethyl acrylate, phosphopropyl methacrylate, phosphopropyl acrylate, phosphobutyl methacrylate, phosphobutyl acrylate, a phosphate ester of  
5 polyethyleneglycol acrylate or methacrylate, a phosphate ester of polypropyleneglycol acrylate or methacrylate, a phosphoalkyl crotonate, a phosphoalkyl maleate, a phosphoalkyl fumarate, a phosphodialkyl acrylate or methacrylate, a phosphodialkyl crotonate, allyl phosphate, or a salt of  
10 any of the foregoing.

5. The aqueous dispersion according to claim 1, wherein the one or more weak acid monomers of the first monomer mixture, or of the second monomer mixture, or both, comprise one or more of: acrylic acid, methacrylic acid, crotonic acid, itaconic acid, fumaric acid, maleic acid,  
15 maleic anhydride, or a salt of any of the foregoing.

6. The aqueous dispersion according to claim 1, wherein the one or more monomers containing a keto group of the first monomer mixture, or of the second monomer mixture, or both, comprise one or more of:  
20 diacetoneacrylamide, diacetone methacrylamide, acetoacetoxyethyl methacrylate, acetoacetoxyethyl acrylate, acetoacetoxybutyl methacrylate, acetoacetoxybutyl acrylate, acetoacetoxypropyl methacrylate, acetoacetoxypropyl acrylate, acrylamidomethylacetylacetone, allyl acetoacetate, or vinyl acetoacetate.

25 7. The aqueous dispersion according to claim 2, wherein the molecule containing multiple -NH<sub>2</sub> or -NH- functionality comprises one or more of: hydrazine, ethylene diamine, propanediamine, butanediamine, hexanediamine, isophorone diamine, piperazine, diethylene triamine,

dipropylene triamine, triethylene tetramine, an oligomer of ethylene diamine, or a poly(ethyleneimine).

5           8. The aqueous dispersion according to claim 2, wherein the polyfunctional carboxylic hydrazide comprises one or more of: adipic dihydrazide, oxalic dihydrazide, isophthalic dihydrazide, or polyacrylic polyhydrazide.

10           9. The aqueous dispersion according to claim 1, wherein the aqueous dispersion further comprises adipic dihydrazide.

15           10. The aqueous dispersion according to claim 1, wherein the one or more strong acid monomers of the second monomer mixture comprise phosphoethyl methacrylate (phosphate ester of 2-hydroxyethyl methacrylate), and the one or more monomers containing a keto group of the second monomer mixture comprise diacetone acrylamide.

20           11. The aqueous dispersion according to claim 1, wherein the one or more strong acid monomers of the second monomer mixture are present in an amount from about 1.0 to about 5.0% by weight based on the weight of the second monomer mixture.

25           12. The aqueous dispersion according to claim 1, wherein the one or more monomers containing a keto group of the second monomer mixture are present in an amount from about 2.0% to about 5.0% by weight based on the weight of the second monomer mixture.

30           13. The aqueous dispersion according to claim 1, wherein the weight ratio of the first monomer mixture with respect to the second monomer mixture is from about 20:80 to about 50:50.

14. The aqueous dispersion according to claim 1, wherein the weight ratio of the first monomer mixture with respect to the second monomer mixture is from about 30:70 to about 40:60.

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15. The aqueous dispersion according to claim 1, wherein the first monomer mixture has a calculated glass transition temperature of at least about 60°C.

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16. The aqueous dispersion according to claim 1, wherein the first monomer mixture has a calculated glass transition temperature of at least about 70°C.

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17. The aqueous dispersion according to claim 1, wherein the second monomer mixture has a calculated glass transition temperature from about -20 to about 0°C.

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18. The aqueous dispersion according to claim 1, wherein a dry film formed from the aqueous dispersion obtains a score of at least 7 on a HOT-BLOCK RESISTANCE TEST.

19. The aqueous dispersion according to claim 1, wherein a dry film formed from the aqueous dispersion obtains a score of at least 8 on a HOT-BLOCK RESISTANCE TEST.